

AD-A121 327

POSITIVE IDENTIFICATION OF MICROGRAM QUANTITIES OF
ASBESTOS USING INFRARED (U) DEFENCE RESEARCH
ESTABLISHMENT PACIFIC VICTORIA (BRITISH COLU
G LUOMA ET AL. SEP 81 DREO-NAT-81-C

1/1

UNCLASSIFIED

F/G 7/4

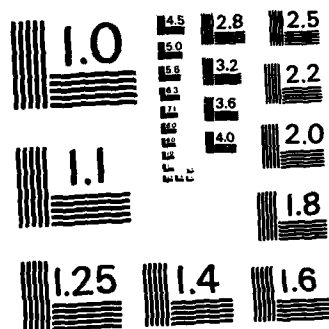
NL

END

FILED

-F

DIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD A 121 327



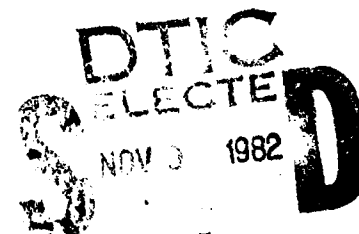
Victoria, B.C.

Materials Report 81-C

**POSITIVE IDENTIFICATION OF
MICROGRAM QUANTITIES OF ASBESTOS
USING INFRARED SPECTROSCOPY**

G.A. Luoma, L.K. Yee and R. Rowland

September 1981



This document has been approved
for public release and sale; its
distribution is unlimited.

Research and Development Branch

Department of National Defence

Canada 82 11 09 016

DTIC FILE COPY

DEFENCE RESEARCH ESTABLISHMENT PACIFIC
VICTORIA, B.C.

Materials Report 81-C

POSITIVE IDENTIFICATION OF MICROGRAM QUANTITIES
OF ASBESTOS USING INFRARED SPECTROSCOPY

by

G. Luoma, L.K. Yee and R. Rowland

September 1981

Approved


Section Head




Chief

RESEARCH AND DEVELOPMENT BRANCH
DEPARTMENT OF NATIONAL DEFENCE
CANADA

ABSTRACT

Because it is highly toxic and carcinogenic to exposed workers, much recent interest has been expressed in identifying and quantifying small amounts of asbestos in many materials. To date, optical microscopy, x-ray diffraction, scanning electron microscopy coupled with energy-dispersive X-ray spectrometry (SEM-EDS), air particle counting, and Raman spectroscopy have all displayed limited applicability to samples of diverse origin. The present report shows that infrared spectroscopy can be used to identify absolutely microgram quantities of various asbestos types in all normally encountered samples. Its main advantages over other methods include ease of sample preparation, speed, and low cost of necessary equipment. When combined with simple purification procedures, it can be used for largely non-asbestos mixtures. Finally, when combined with present day microcomputer systems, automatic semiquantitative identification of mixtures of different asbestos types can be made.

- 1 -



A

1. INTRODUCTION

In the past ten years, asbestos has been found to cause a number of serious illnesses among mine workers. The major illnesses, asbestosis and mesothelioma are caused by the direct inhalation of asbestos fibers into the throat and lungs^{1,2}. Therefore, monitoring air samples in areas exposed to asbestos dust is becoming increasingly important. Other experiments suggest that certain types of asbestos belonging to the amphibole class are potentially more dangerous than those belonging to the serpentine class^{3,4}. This latter observation is directly related to particle size and shape, since amphiboles are usually composed of larger, needlelike fibers which can cause more tissue damage. As a result, determination of asbestos type is also important in assessing potential harmful effects.

As mentioned above, there are two basic classes of asbestos: the serpentines and the amphiboles. The only member of the serpentine class is chrysotile asbestos, and it is obtained almost exclusively from Canada and Rhodesia. It composes approximately 95% of the asbestos found in industrial applications⁵. The amphibole class contains three commonly encountered species called amosite, crocidolite and anthophyllite, as well as tremolite. The major types and their chemical formulae are contained in Table I.

TABLE I: Commonly occurring types of asbestos

Asbestos Type	Formula	% OH by weight
<u>serpentine</u> chrysotile	$Mg_3(Si_2O_5)(OH)_4$	25%
<u>amphiboles</u> amosite	$(Mg, Fe^{+2})_7(Si_8O_{22})(OH)_2$	~5%
crocidolite	$Na_2Fe^{+3}_2Fe^{+2}_3(Si_8O_{22})(OH)_2$	~5%
anthophyllite	$(Mg, Fe^{+2})_7(Si_8O_{22})(OH, F)_2$	~2%

Although many asbestos substitutes are currently available, the complete replacement of asbestos has not been achieved⁶. At present, asbestos is still used in such products as fire blankets, lagging materials for heat pipes and electronics, gaskets and cement. About 3.5 million tons of asbestos are consumed each year, so methods for its identification are still required.

Much current experimentation concerned with developing positive detection of small amounts of asbestos has been carried out. The major methods used are polarized light microscopy, x-ray diffraction and scanning electron microscopy coupled with energy-dispersive X-ray spectrometry (SEM-EDS)⁷⁻¹⁰. Other less common methods include thermal methods such as differential scanning calorimetry (DSC) and Raman spectroscopy^{11,12}. All of these techniques produce very good qualitative, and sometimes quantitative, results for specific analyses, but none has been shown to be generally applicable to all

asbestos analyses. Furthermore, some are time consuming and not truly confirmatory (e.g. light microscopy), others require fairly large sample volumes (e.g. X-ray diffraction), and still others require expensive specialized equipment (e.g. SEM-EDS). Therefore, a fast identification technique having a wide general applicability and requiring only small samples is required.

A few infrared studies of asbestos have been reported¹³⁻¹⁶. Unfortunately, most of them have had limited success either because of the low sensitivity of older infrared spectrophotometers or the limited spectral range (4000 to 600 cm^{-1}). Patterson and O'Connor¹³ originally showed that amosite and crocidolite contain strong and characteristic SiO infrared absorption bands at 1200-900 cm^{-1} , and these bands were also found for chrysotile by Beckett et al¹⁴. For chrysotile asbestos, a further characteristic sharp OH peak at 3670 cm^{-1} was also reported^{14,15}. Finally, the region between 800 cm^{-1} and 200 cm^{-1} was shown to contain a characteristic pattern of peaks which could be successfully used to classify asbestos types¹⁶.

The use of infrared spectroscopy for the analysis of mixtures containing asbestos has been hampered by the presence of interfering bands of the non-asbestos matrix¹⁵. However, the advent of computer methods and multiple scanning techniques have resulted in the ability to detect low limits of asbestos and the presence of a small proportion of asbestos in a non-asbestos matrix¹⁶.

In this report, we present infrared data for the common types of asbestos used in industry and by the armed forces. We also show that infrared sensitivity and selectivity are as good as all other techniques, and that infrared spectroscopy can have superior capability when used on mixtures.

II. EXPERIMENTAL:

When preparing asbestos-containing samples for infrared analysis, the amount of pretreatment necessary is dependent on the source and purity of the sample. In all, three different procedures were performed and are briefly described below.

1. If the sample of asbestos is relatively pure, or a single fiber can be easily isolated, approximately 100 μ g of sample is ground up in a mortar with approximately 10 mg of potassium bromide (KBr). The resulting mixture is pressed into a 5 mm diameter pellet and inserted directly into the infrared spectrophotometer. If small sample sizes are necessary, as little as a few micrograms of asbestos can be analysed in a 3 mm diameter pellet using a beam condenser attachment.
2. If the sample contains large amounts of impurities which produce interfering infrared bands, the high resistance of asbestos to acids and bases can be used to purify it from contaminating organic and metal components. The following method was successfully employed.
 - (a) Stir the asbestos sample (preground) into twenty volumes of concentrated sulfuric acid and suction filter on a sintered glass funnel. Wash with distilled water.
 - (b) Stir the partly purified asbestos in twenty volumes of concentrated ammonia. Wash with distilled water.
 - (c) Rinse the pure asbestos with twenty volumes of acetone and filter. Oven dry at 120°C.

The sample can then be ground and pelletized as before. If the weights of the original and final purified samples are recorded, a semi-quantitative estimate of the proportion of asbestos in the original sample can be made.

3. In some cases, impurities in the asbestos-containing samples are best removed by pyrolysis. In such cases, a small amount of sample is placed in a crucible and is heated on a bunsen flame until all impurities are driven off. However, this procedure is less desirable since pyrolysis alters the asbestos, and produces an inferior infrared spectrum (see Section IIIF).

Pure asbestos samples were obtained from Duke Scientific. All infrared spectra were recorded on a Perkin-Elmer 398 Infrared Spectrophotometer equipped with a Model 3600 Data Station.

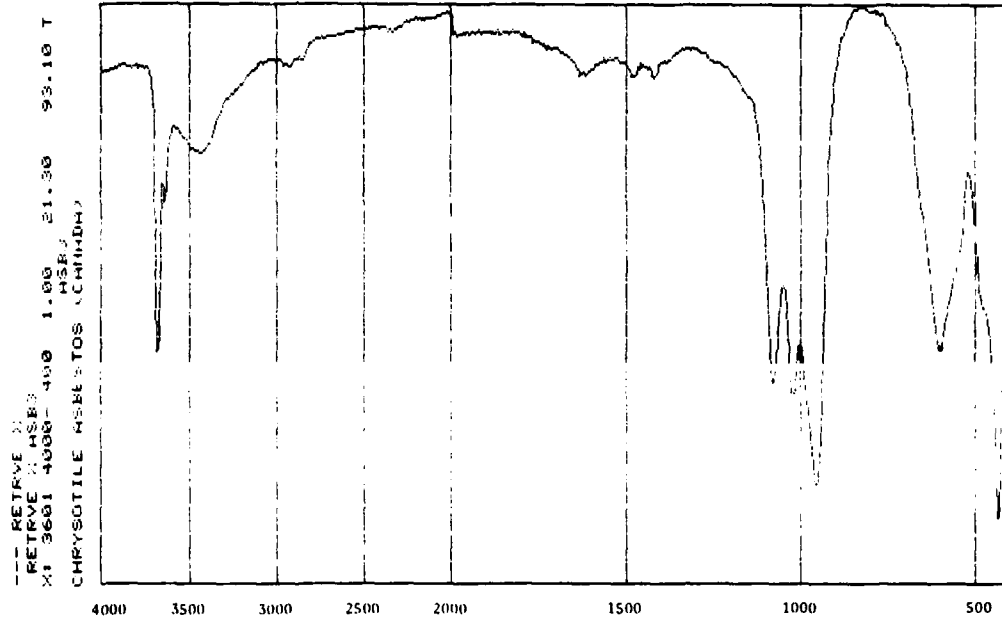
III. RESULTS:

A. Infrared Spectra of Serpentine and Amphibole Standards and Their Characteristic Bands.

As mentioned in the introduction, there are two classes of asbestos; the serpentine class made up of chrysotile, and the amphibole class containing amosite, crocidolite and anthophyllite. The infrared spectra of each type are shown in Figure 1.

Figure 1. Some commonly used asbestos types.

(a) chrysotile asbestos from Canada



(b) chrysotile asbestos from Rhodesia

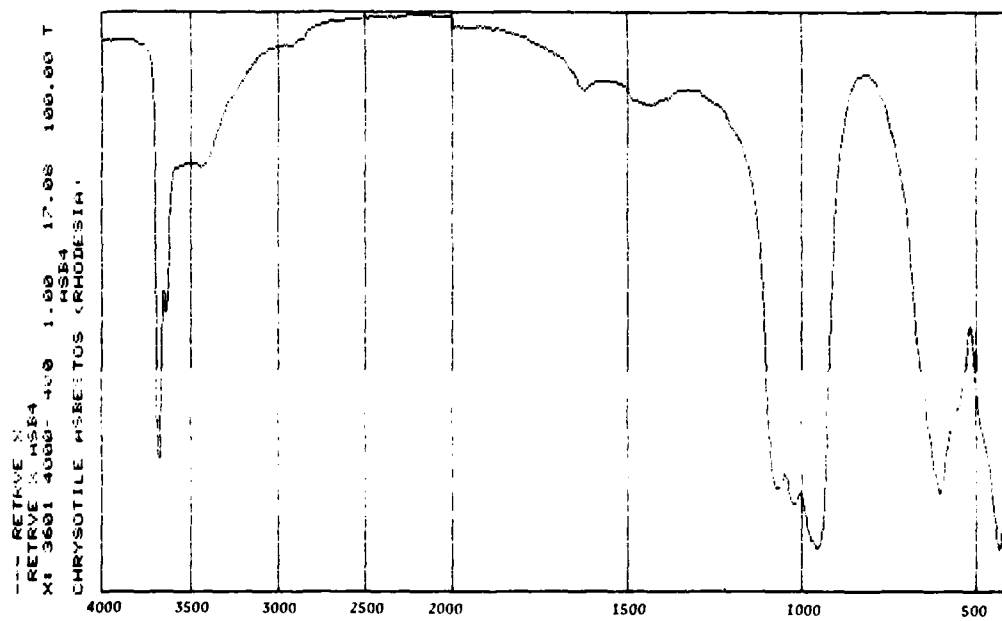
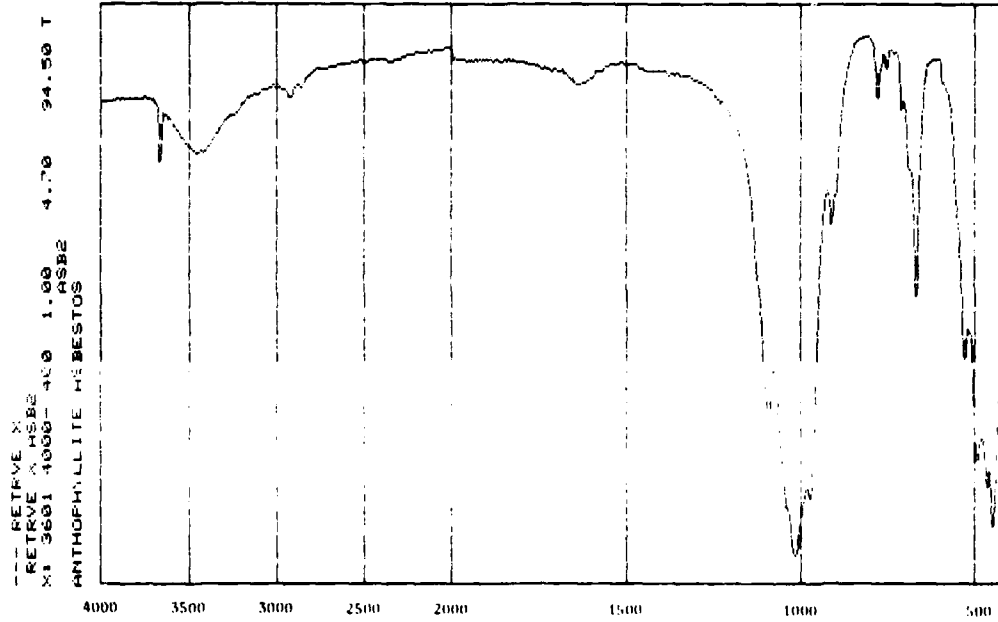


figure 1 (cont.)...

(c) anthophyllite asbestos



(d) amosite asbestos

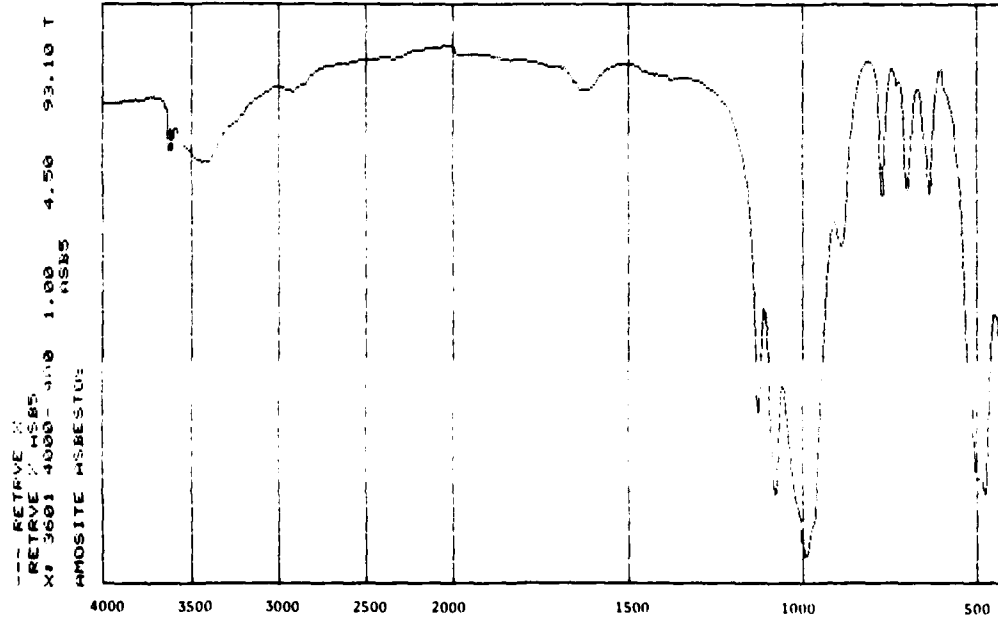
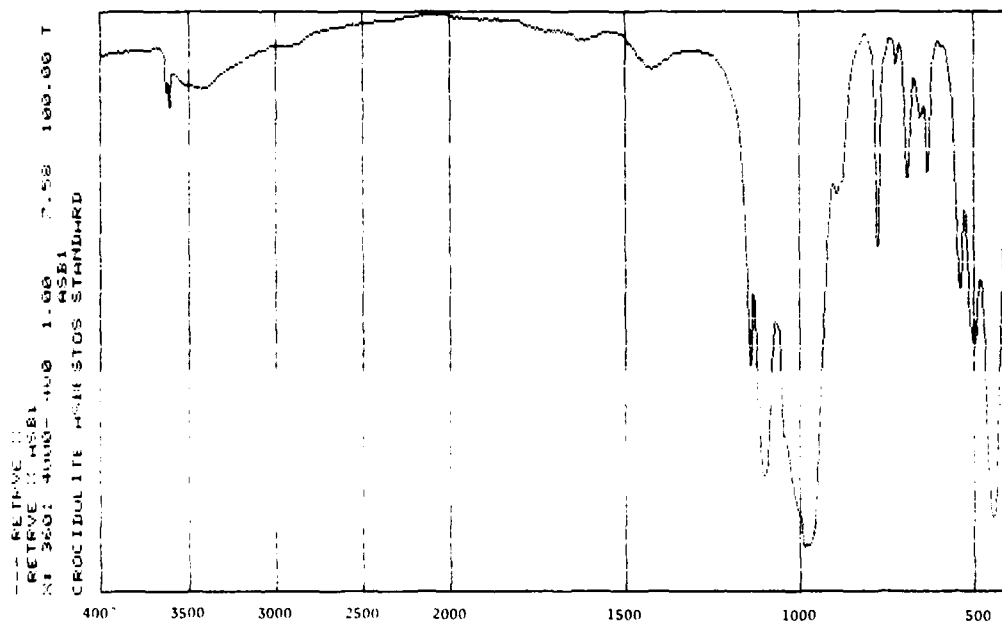


figure 1 (cont.)...

(e) crocidolite asbestos

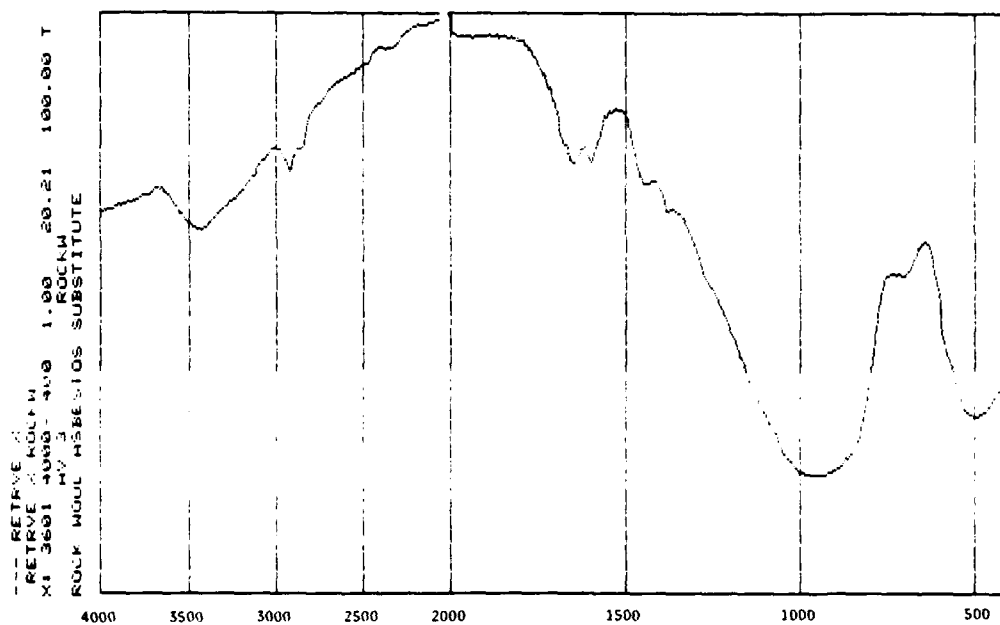


B. Infrared Spectra of Some Common Asbestos Substitutes.

Asbestos substitutes are generally of three types: glass fiber cloths, man-made fiber cloths impregnated with fire-retardant chemicals, and natural non-asbestos mineral blends. Some infrared spectra of representative samples of each type of substitute are contained in Figure 2.

Figure 2. The infrared spectra of some commonly used asbestos substitutes.

(a) rock wool



(b) lageeze 84205 glass fiber lagging material

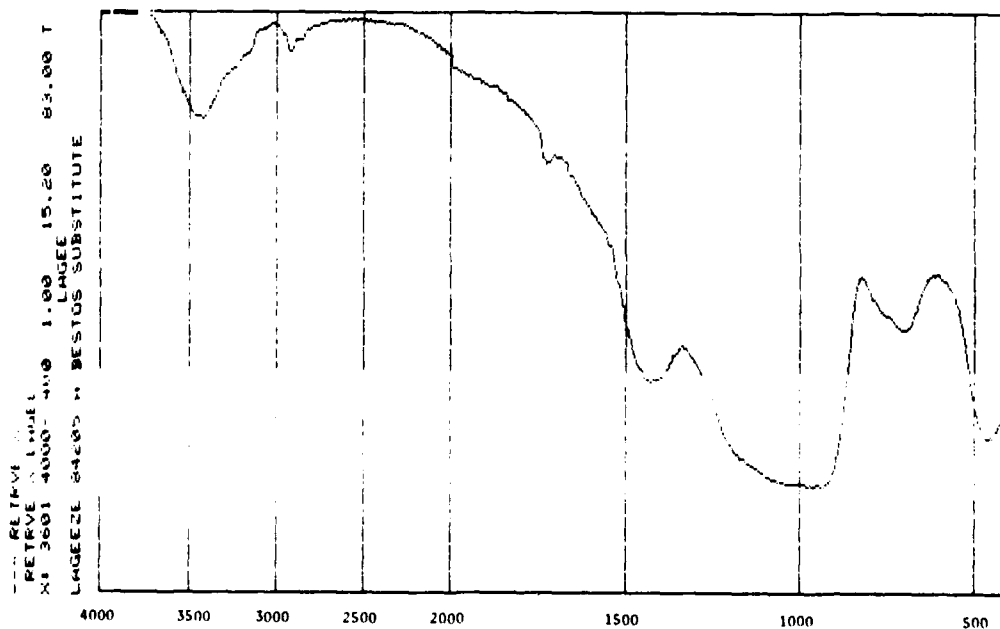


figure 2 (cont.)...

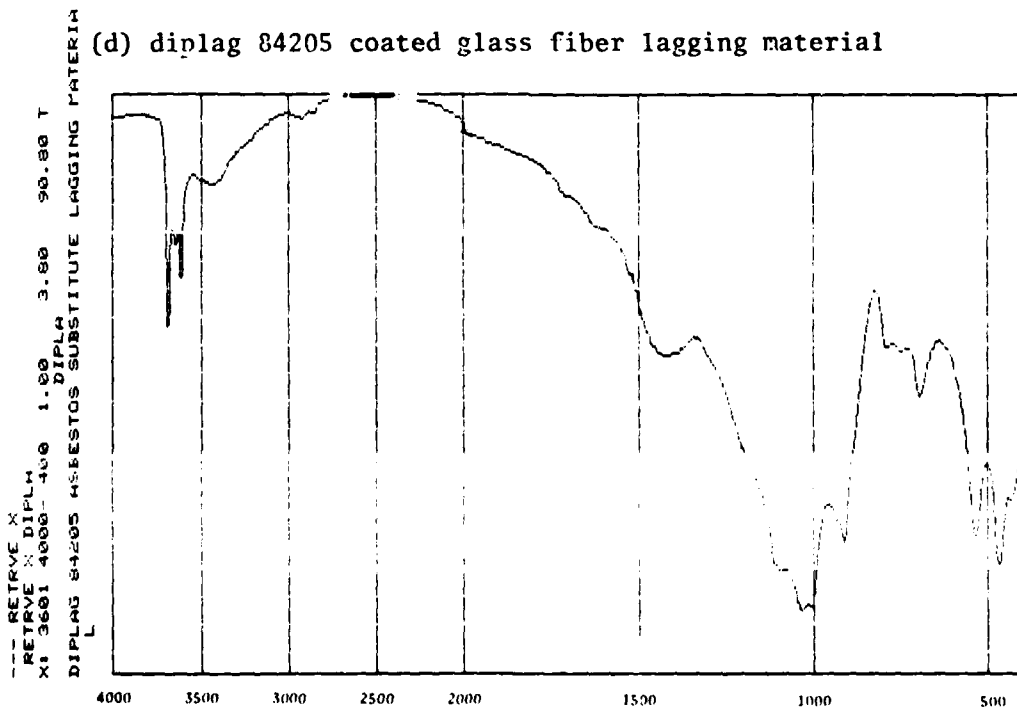
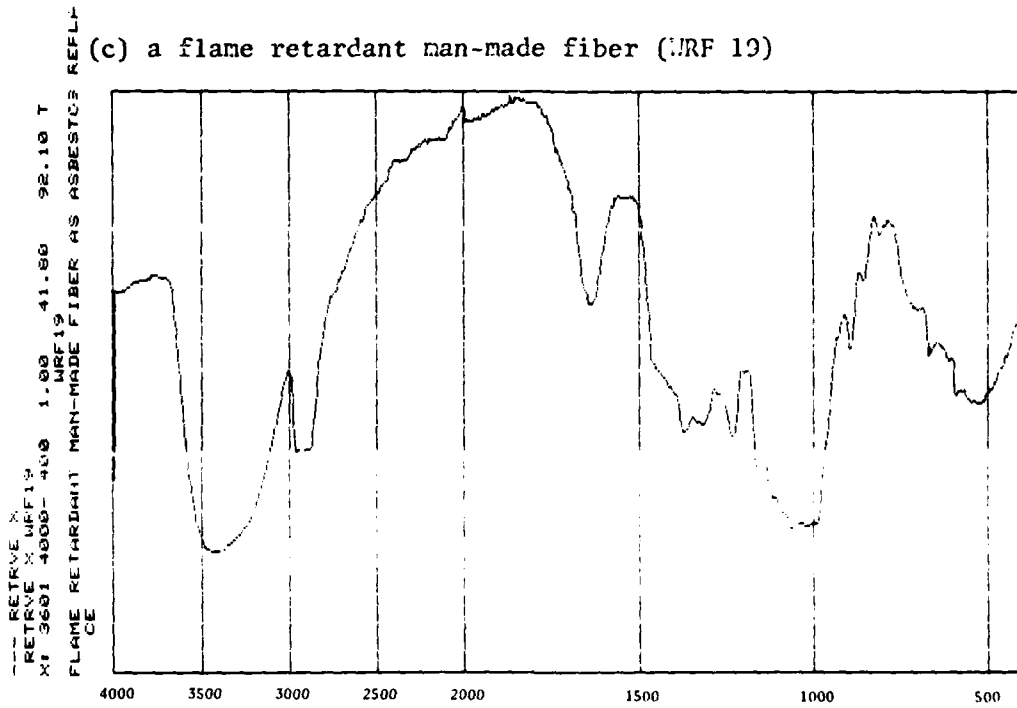
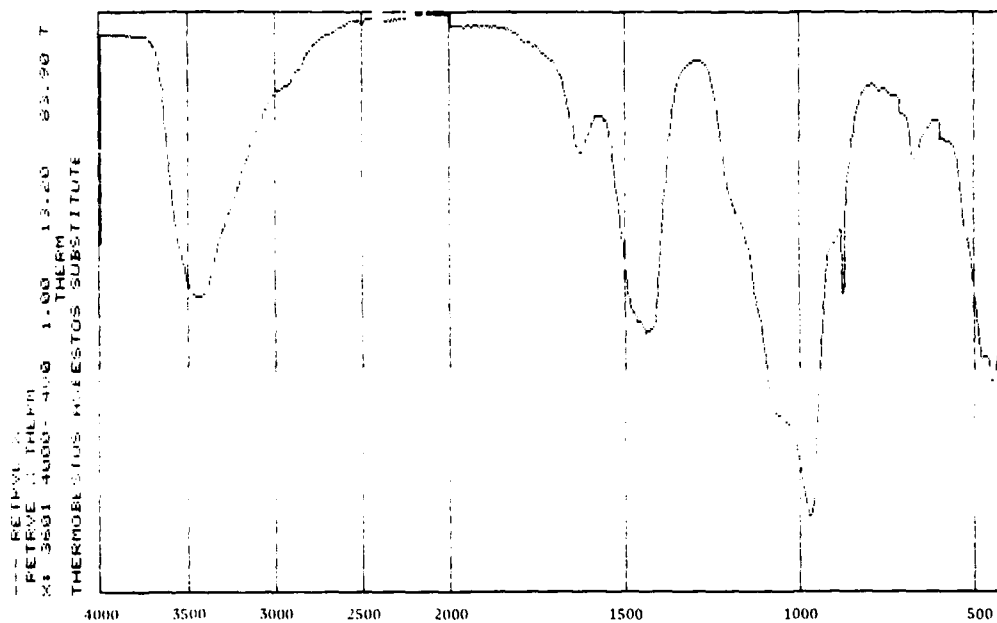


figure 2 (cont.)...

(e) thermobestos inorganic substitute



(f) atlacite inorganic substitute

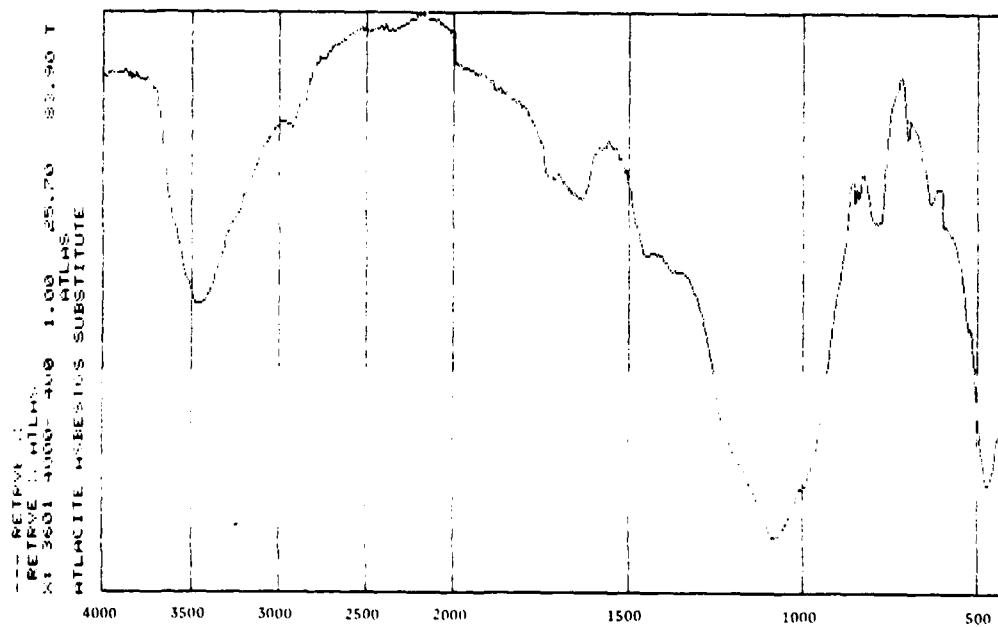
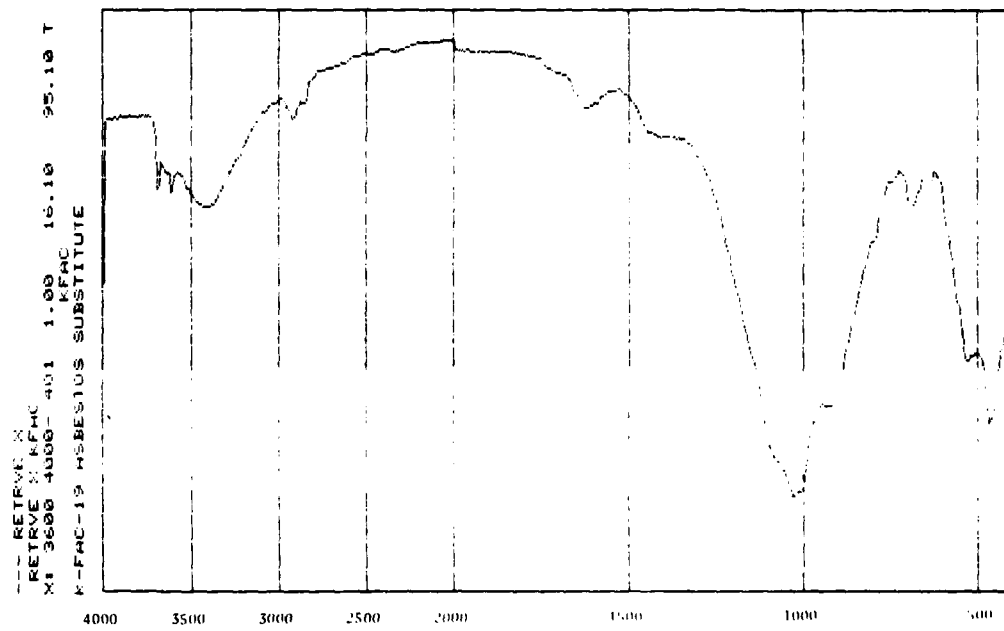


figure 2 (cont.)...

(g) K-FAC-19



Analyses of these spectra show that most amphiboles have a characteristic band between 770cm^{-1} and 780cm^{-1} , which is absent in chrysotile asbestos. Furthermore chrysotile asbestos has a characteristic strongly absorbing doublet around $3600\text{--}3700\text{cm}^{-1}$, which is reduced in intensity or absent in the amphiboles. This doublet is due to OH vibrations of bound hydroxyls in the crystal structure, and the chrysotile asbestos has a higher proportion of OH groups than the amphiboles, resulting in the increased intensity. Finally, chrysotile asbestos lacks any sharp absorption bands between 900cm^{-1} and 650cm^{-1} , while the amphiboles each have characteristic peaks in this region. Therefore, the differences between chrysotile and amphibole asbestos types are readily discriminated.

Among the amphiboles, crocidolite and amosite have a sharp peak between 1120cm^{-1} and 1140cm^{-1} , while such a band is conspicuously absent in the anthophyllite asbestos spectrum. Furthermore, the three amphiboles have unique patterns of sharp bands between 800cm^{-1} and 400cm^{-1} which make identification simple. The characteristic pattern of these bands is due to the variety of SiO stretching and bending vibrations for various crystal structures.

Although chrysotile is the only serpentine asbestos found, its infrared spectrum varies with place of origin. Thus, Canadian chrysotile is characterized by sharper bands, and the more intense peak at 430cm^{-1} , in contrast to the chrysotile from Rhodesia. The positions of major bands for each of the asbestos types is contained in Table. 2.

TABLE II: Infrared Peaks of major asbestos types

Asbestos Type				
Crocidolite	Amosite	Anthophyllite	Chrysotile I*	Chrysotile II
3627 cm^{-1}	3629 cm^{-1}	3667 cm^{-1}	3681 cm^{-1}	3681 cm^{-1}
3611	3609	3547	3637	3637
3416	3511	3413	3434	3434
1141	3410	2849	3380	3380
1100	3236	1257	1079	1079
986	1617	1094	1022	1022
973	1126	1015	954	954
894	1080	975	721	721
777	993	912	605	605
725	888	781	600	600
692	773	755	435	435
655	729	712		
634	701	670		
541	637	531		
501	495	495		
447	480	465		
	425	450		

* Chrysotile I: Chrysotile asbestos from Canada

Chrysotile II: Chrysotile from Rhodesia

The infrared spectra of the glass fiber substitutes are characterized by very broad unresolved bands. The most characteristic bands are the broad OH stretch at 3400 cm^{-1} , the SiO band at $1200\text{--}900\text{ cm}^{-1}$ and the band at 500 cm^{-1} .

The infrared spectra of the man-made fiber substitutes are characterized by contributions from both the fiber matrix and the fire retardant chemical. The most noticeable differences between these and the other substitutes are the presence of the CH stretch bands around 2900 cm^{-1} and the large number of sharper peaks which are characteristic of organic components.

The infrared spectra of non-asbestos mineral substitutes contain bands between 1200 cm^{-1} and 800 cm^{-1} characteristic of silicates. They also contain broad OH bands at 3400 cm^{-1} . Finally, some, (e.g. thermobestos), contain a strong broad band at 1450 cm^{-1} and a sharp band at 870 cm^{-1} which are characteristic of the presence of a carbonate component.

In summary, all of the asbestos substitutes produce characteristic information from their infrared spectra. The spectra are substantially different from those of any of the asbestos types, and they can be readily differentiated as non-asbestos materials.

C. Infrared Analyses of Samples Containing Asbestos and Non-Asbestos Components.

To test the utility of infrared spectroscopy for the analysis of samples largely composed of non-asbestos materials three typical products were analyzed: a) an asbestos-containing rubber gasket used in steam drums of naval vessels; b) a mixture of diatomaceous earth containing 10% asbestos; and c) an asbestos fire blanket containing a chemical binder. In all cases, spectra were recorded both before and after acid/base washing and

are shown in Figures 3-5.

Figure 3. (a) A spectrum of a boiler gasket material composed of asbestos-impregnated rubber. (b) The same gasket material after washing with sulfuric acid, ammonia and acetone to remove organic components. Note how the washing procedure produces a high quality asbestos spectrum.

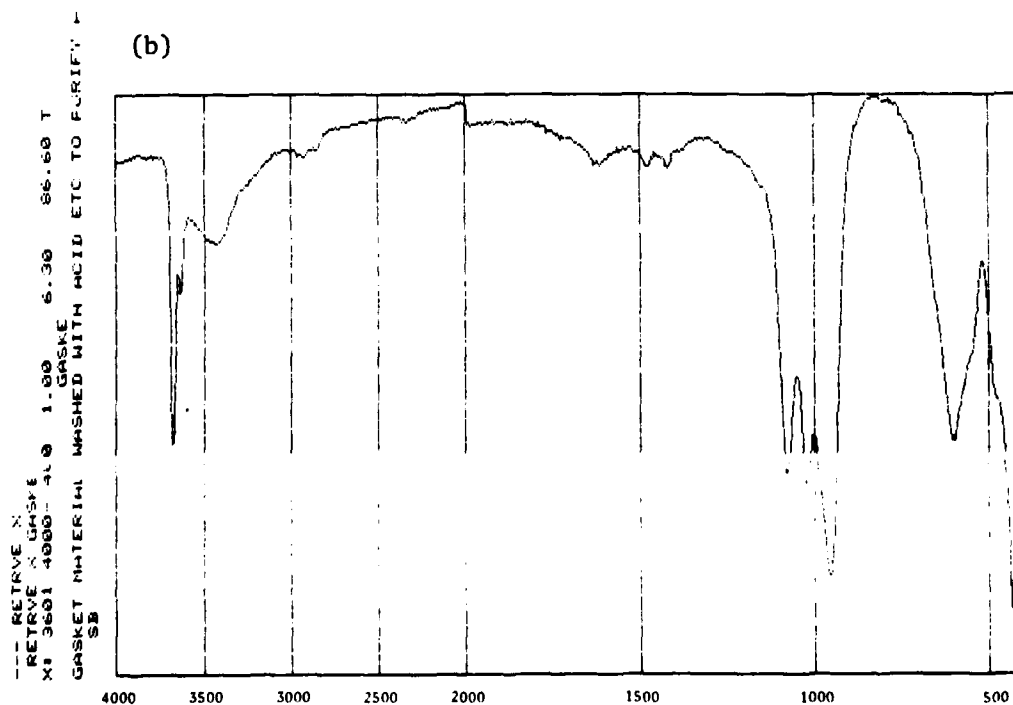
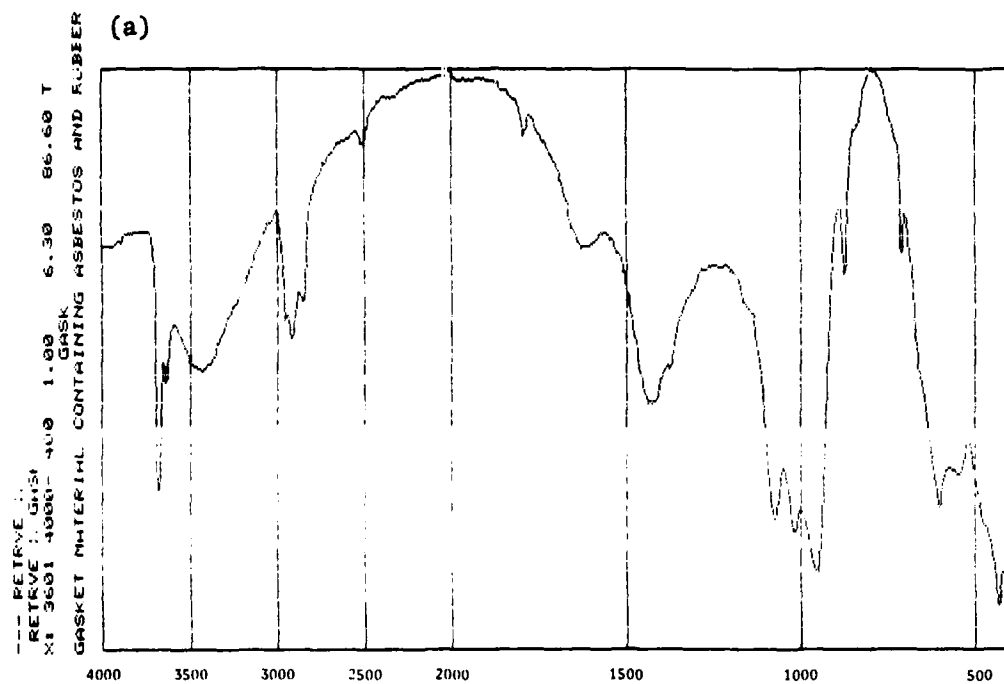


Figure 4. (a) An infrared spectrum of fire blanket material containing fiberglass and asbestos and a small amount of organic binder. (b) The same blanket material after washing.

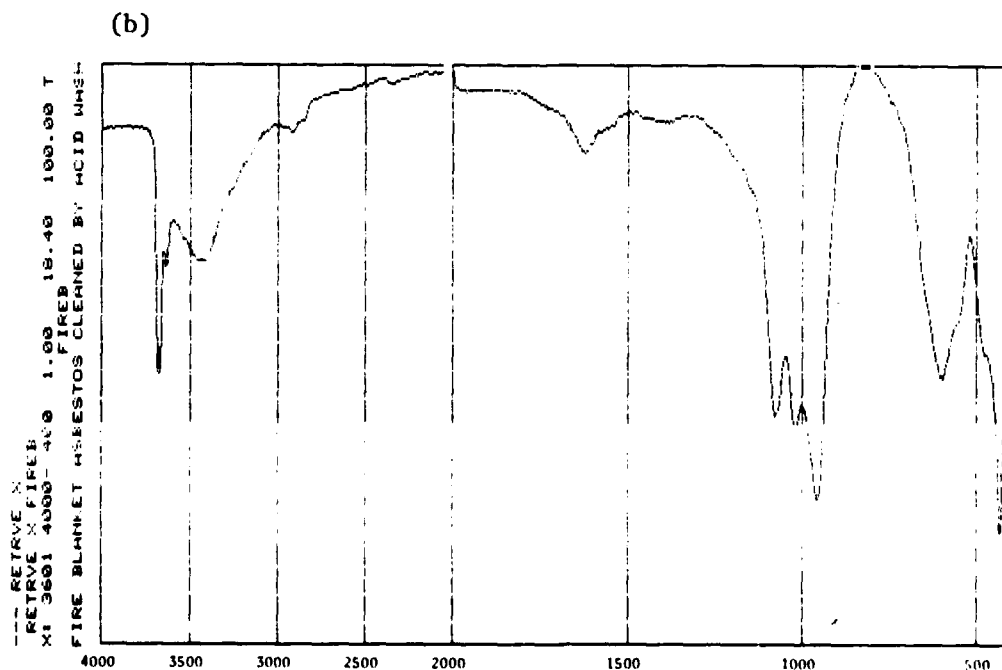
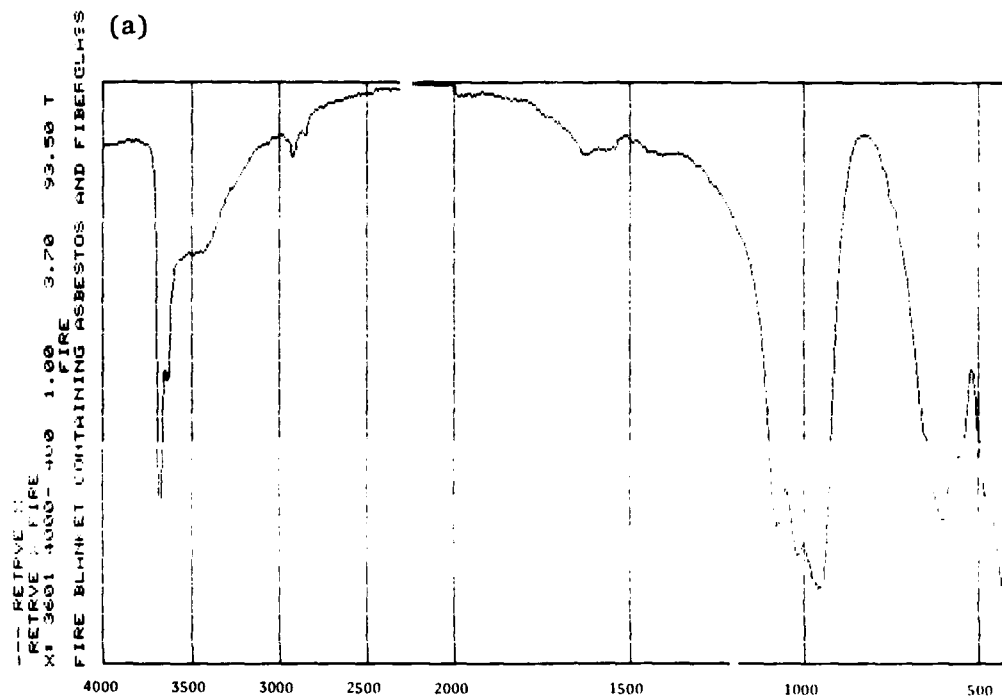
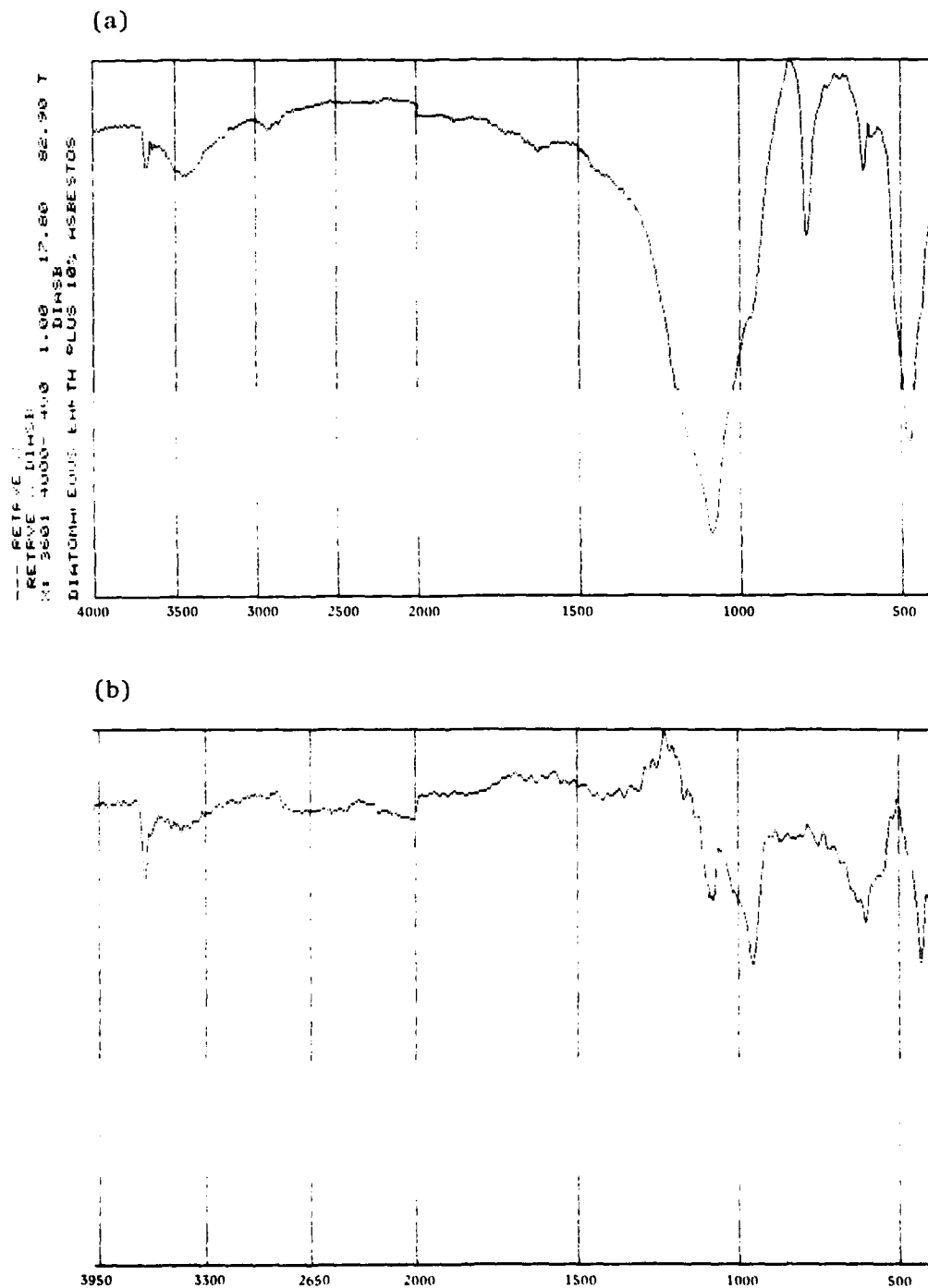


Figure 5. (a) The infrared spectrum of a sample of diatomaceous earth containing 10% asbestos. Note that the asbestos spectrum is almost completely masked by the diatomaceous earth spectrum. (b) The same spectrum as in (a) except the spectrum of diatomaceous earth has been computer subtracted to produce a difference spectrum which can be positively identified as asbestos.



For the untreated asbestos-rubber gasket, the infrared spectrum shows definitively the presence of chrysotile asbestos (cf. Figure 1(a)), as well as an organic component (bands at 2900 cm^{-1}) which is known to be natural rubber. The characteristic asbestos bands show very little interference from the infrared bands of the rubber component. Furthermore, purification by acid/base washing causes the rubber component to be removed from the asbestos, without affecting the structure of the asbestos. The resulting infrared spectrum is identical to that of pure Canadian chrysotile asbestos.

The spectra of the fire blanket before and after treatment are contained in Figure 4. Again the presence of chrysotile asbestos is confirmed even in the untreated blanket. Also, two isolated bands at 2900 cm^{-1} and 790 cm^{-1} indicate the presence of the organic binding agent. The acid/base washing eliminated this organic compound, and the resulting infrared spectrum is identical to chrysotile asbestos.

Finally, to show the power of infrared spectroscopy when combined with modern computer accessories, a synthetic mixture of 10% asbestos in diatomaceous earth (amorphous silica) was analysed (Figure 5). The spectra of the mixture and pure diatomaceous earth are very similar. This is because of the similarity of the chemical compositions of amorphous silica and asbestos, and the large infrared contribution of the silica masks the asbestos spectrum. Furthermore, the acid and base washing procedure would not remove the silica from the sample. However, when the difference spectrum of the mixture minus the diatomaceous earth is obtained using computer subtraction methods (Figure 5(b)), the resultant is a spectrum of the asbestos portion of the mixture. Although the resolution and signal-to-noise of the difference spectrum is reduced, it can still be positively identified as chrysotile asbestos.

D. Infrared Spectra of Mixtures of Asbestos Types

As well as identifying asbestos as a minor component in a non-asbestos matrix, mixtures of two or more asbestos types can be analysed by infrared spectra using computer-aided spectral additions (Figure 6). In this case, a suspected asbestos mixture submitted for analysis by Canadian Forces personnel was used.

Figure 6. (a) The infrared spectrum of a sample containing two kinds of asbestos and a third non-asbestos component. (b) A computer simulated spectrum was composed of 40% chrysotile asbestos, 30% amosite asbestos and 30% diatomaceous earth. Note how this simulation not only allows the major components to be identified but also to be semi-quantitatively determined.

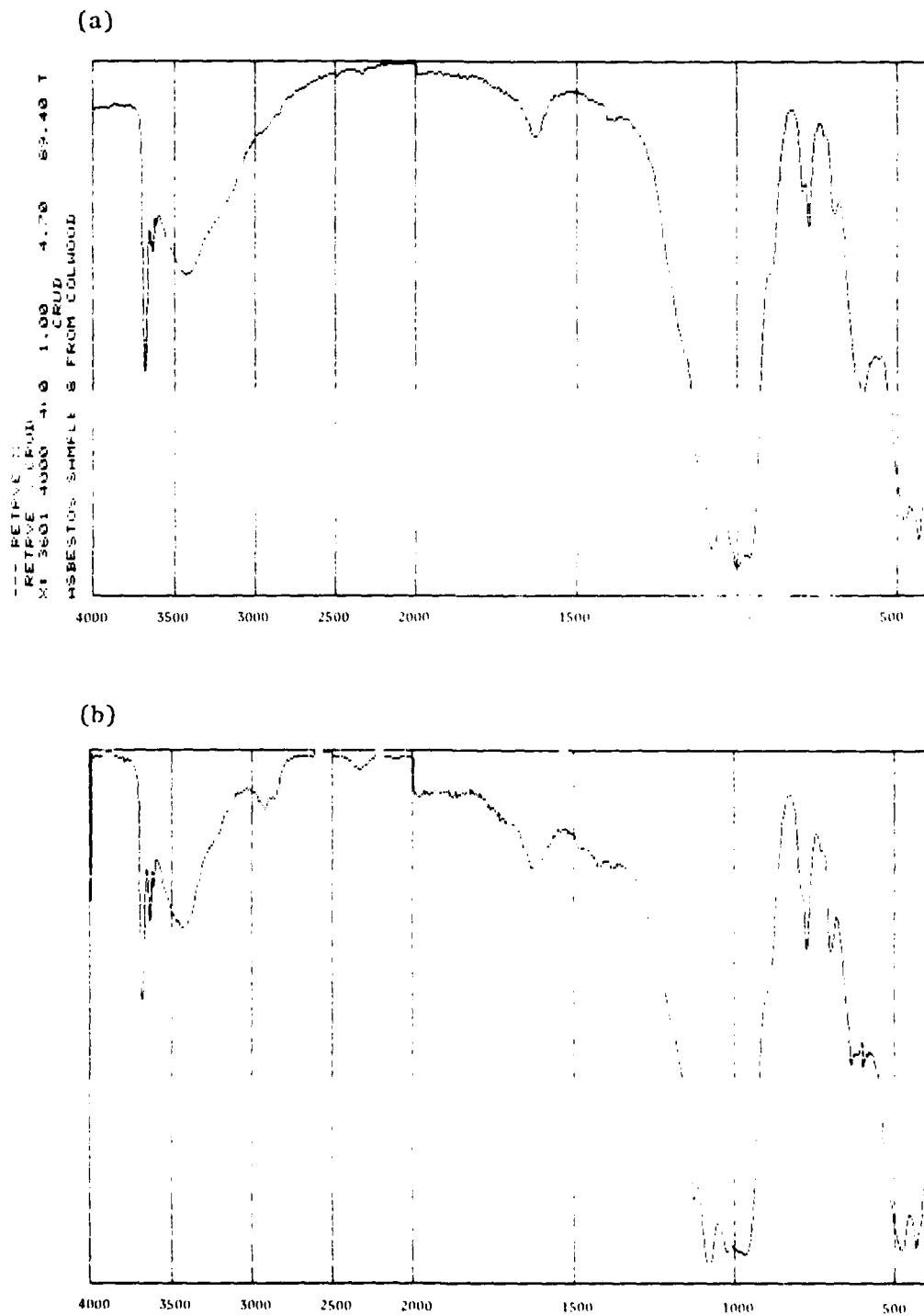


Figure 6(a) is the experimental spectrum, and it contains the typical OH vibrations at 3620 and 3670 cm^{-1} due to the presence of chrysotile asbestos. However, the SiO region of the spectrum (1200 cm^{-1} to 900 cm^{-1}) is not typical of chrysotile asbestos alone. Furthermore, the region of $800\text{--}600\text{ cm}^{-1}$ contains some sharp bands typical of amphibole type asbestos, especially the band at 775 cm^{-1} . Figure 6(b) shows a computer simulated spectrum obtained by combining spectra of chrysotile and amosite asbestos. As can be seen, the experimental spectrum is well matched by a simulated spectrum consisting of approximately 40% chrysotile asbestos, 30% amosite asbestos, and 30% diatomaceous earth. The presence of both amosite and chrysotile asbestos was confirmed by x-ray diffraction, but the diatomaceous earth cannot be detected because of its amorphous character. Therefore, for this example, infrared analysis proved superior for estimating quantities of components in a mixture containing multiple types of asbestos or non-asbestos materials.

E. The Detection Limit of Asbestos by Infrared Spectroscopy

Since allowed levels of contamination by asbestos in working environments are low, a useful analytic technique must be able to accurately detect small quantities of asbestos. Therefore, the detection limit by infrared spectroscopy was investigated. Figure 7 contains the spectrum of $10\text{ }\mu\text{g}$ of chrysotile asbestos pelletized in 3 mg of potassium bromide using a Perkin Elmer beam condenser accessory and a 3 mm pellet. The figure shows that even a single scan of this small amount produces a high quality spectrum. The amount of sample used can be further reduced by using a 1 mm diameter micropellet and a spectrum with substantially less signal-to-noise could be tolerated. Therefore, infrared spectroscopy can

positively identify asbestos in sub-microgram quantities.

Figure 7. The sensitivity of infrared for detection of microgram quantities of asbestos is demonstrated. The figure shows that a single scan of a sample of 10 micrograms of asbestos produces a high quality spectrum using a beam condenser accessory.

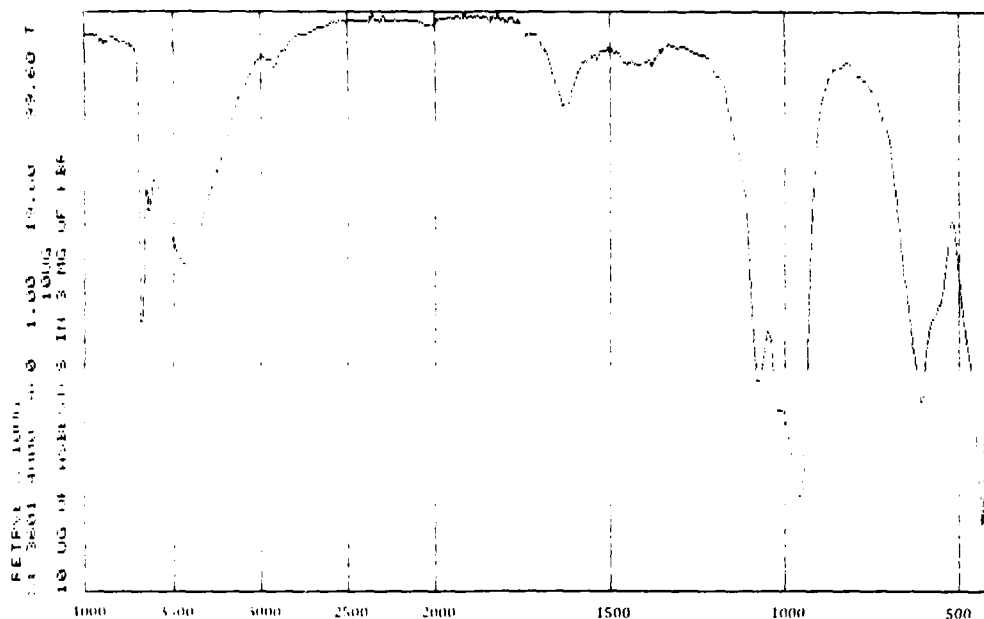
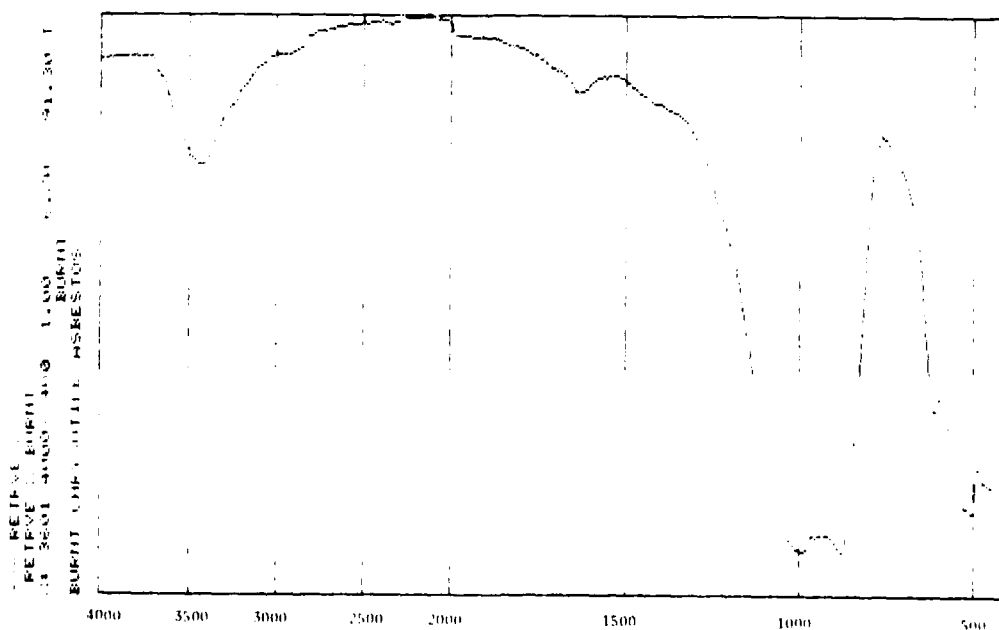


Figure 8. The infrared spectrum of burnt chrysotile asbestos. Note the loss of both resolution and the characteristic OH bands.



F. Pyrolysis of Asbestos and Infrared Analysis

In some samples containing asbestos, pyrolysis may be a more convenient way to purify the asbestos sample. However, x-ray diffraction studies suggested that the asbestos structure is altered by pyrolysis. The infrared spectra of pyrolysed chrysotile asbestos confirms that a structural change has taken place, resulting in the loss of the characteristic sharp peaks at 3620 cm^{-1} and 3670 cm^{-1} (Figure 8). Also the other peaks are shifted and less well resolved. Therefore, pyrolysis should be used with infrared analysis of asbestos only when necessary to remove interferences by other components.

IV. DISCUSSION AND CONCLUSIONS:

The above results indicate the utility of infrared spectroscopy for the identification of asbestos materials. Not only can mixtures of asbestos in non-asbestos matrices be analysed, but mixtures of various types of asbestos can be compared to simulated spectra. The detection limit is extremely low (less than 1 μ g) for a single infrared scan in a micropellet. This low detection limit can be further increased by the use of multiple scan accumulations in modern dispersive instruments, and by the use of Fourier Transform Infrared Spectrometers.

The main advantages of infrared analysis are three fold:

1. It gives positive identification of every kind of asbestos in almost all samples. The only exceptions are extremely small proportions of asbestos in similar compounds which cannot be removed by acid and base pretreatments.
2. Infrared analyses as asbestos samples are fast. In most cases positive identification can be obtained in ten minutes.
3. The use of minicomputers can automate the identification procedure. Infrared spectra of asbestos standards can be stored on computer discs, and experimental spectra can be automatically compared and identified with these files.

ACKNOWLEDGEMENT:

The authors gratefully acknowledge the assistance of B. Kaye for providing samples, information and running x-ray diffraction patterns as confirmations for the infrared spectra.

REFERENCES

1. M.R. Becklake, American Review of Respiratory Disease 114 (1976), 187.
2. V. Timbrell, Annals of the New York Academy of Science 132 (1965), 255.
3. J.S. Harrington, J.C. Gilson, and J.C. Wagner, Nature 232 (1971), 54.
4. V. Timbrell, D.M. Griffiths, and F.D. Pooley, Nature 232 (1971), 55.
5. Duke Scientific Corporation, "Asbestos Properties", April 1979.
6. Department of National Defence Canada, "Specification #D-03-011-001/SF-000", April 1, 1980.
7. W.C. McCrone, The Microscope 28 (1977), 251.
8. K.I. McRae and C.A. Waggoner, Defence Research Establishment Pacific Technical Memorandum 80-10, December 1980.
9. B.A. Lange and J.C. Haartz, Analytic Chemistry 51 (1979), 520.
10. A.L. Rickards, Analytical Chemistry 45 (1973), 809.
11. D.H. Hamer, F.R. Folie, and J.P. Shelz, American Industrial Hygiene Association Journal 37 (1976), 296.
12. J.J. Blaha and G.J. Rosasco, Analytical Chemistry 50 (1978), 892.
13. J.H. Patterson and D.J. O'Connor, Australian Journal of Chemistry 19 (1965)
14. S.T. Beckett, A.P. Middleton, and J. Dodgson, Annals of Occupational Hygiene 18 (1975), 313.
15. R.P. Bagioni, Environmental Science Technology 9 (1975), 262.
16. J.P. Coates, Perkin Elmer Infrared Bulletin IR 141 (1978).

Distribution

Report No. DREP Materials Report 81-C

Title: Positive Identification of Microgram Quantities of Asbestos using Infrared Spectroscopy

Authors: G. Luoma, L.K. Yee and R. Rowland

Dated: September 1981

Security Grading: Unclassified

2-DSIS Circ. CRAD
CRAD Attn: DSTOV-2

Plus distribution:

1 - DSIS Report Collection	2 - CANMAR PAC
1 - Document Section (microfiche)	1 - CO SRU(P)
1 - DREA	1 - CO NEU(P) Attn: EN3
2 - DREA/DL	1 - CFFS Esquimalt
1 - DREV	1 - CANCOMTRAINPAC/CANCOMTRAINRON
1 - DCIEM	1 - CANCOMDESRON 2

1 - CEM	2 - DGMEM
1 - DEMPS	1 - DMPM
4 - DGAEM	1 - DMEE
2 - DAPM	1 - DMES
2 - DAEM	2 - DGLEM
2 - DAES	
2 - CFB Shearwater, N.S.	
1 - CFB Comox, B.C.	
1 - CFB Edmonton, Alta.	
1 - CFB Cold Lake, Alta.	
1 - QETE	
1 - NETE	
1 - LETE	
2 - AMDU	

2 - CANMARCOM
1 - COMTECHLANT
1 - CANCOMDESRON 5
1 - COSRUA(A)
1 - RMC, Kingston
Attn: Dept. Mech. Eng.
1 - CDLS/W
1 - CDLS/L
1 - DRA (Paris)

BRITAIN

5 - DRIC
Plus Distribution
1 - AMTE
1 - RAE
1 - NAML
1 - AOL

2 - BDLS

UNITED STATES

3 - DTIC

AUSTRALIA

1 - Aeronautical Research Laboratories
Fishermens Bend, Melbourne
1 - Materials Research Laboratories
Maribyrnong

NEW ZEALAND

1 - Defence Scientific Establishment
HMNZ Dockyard
Auckland 9, N.Z.

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATING ACTIVITY Defence Research Establishment Pacific CFB Esquimalt, B.C. FMO Victoria, B.C. VOS 1B0		2a. DOCUMENT SECURITY CLASSIFICATION UNCLASSIFIED	
		2b. GROUP I	
3. DOCUMENT TITLE Positive Identification of Microgram Quantities of Asbestos Using Infrared Spectroscopy			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Materials Report			
5. AUTHOR(S) (Last name, first name, middle initial) Luoma, Greg A.; Yee, Lannie K.; and Rowland, Robert			
6. DOCUMENT DATE September 1981		7a. TOTAL NO. OF PAGES 30	7b. NO. OF REFS 16
8a. PROJECT OR GRANT NO.		9a. ORIGINATOR'S DOCUMENT NUMBER(S) Materials Report 81-C	
8b. CONTRACT NO.		9b. OTHER DOCUMENT NO.(S) (Any other numbers that may be assigned this document)	
10. DISTRIBUTION STATEMENT Unlimited			
11. SUPPLEMENTARY NOTES		12. SPONSORING ACTIVITY Materials Engineering Section Defence Research Establishment Pacific CFB Esquimalt, B.C. VOS 1B0	
13. ABSTRACT Because it is highly toxic and carcinogenic to exposed workers, much recent interest has been expressed in identifying and quantifying small amounts of asbestos in many materials. The present report shows that infrared spectroscopy can be used to identify absolutely microgram quantities of various asbestos types in all normally encountered samples. When combined with simple purification procedures, it can be used for largely non-asbestos mixtures. Finally, when combined with present day microcomputer systems, automatic semiquantitative identification of mixtures of different asbestos types can be made.			

KEY WORDS

Infrared spectroscopy
asbestos identification
quantitative
mixtures
non-asbestos substitutes

INSTRUCTIONS

1. **ORIGINATING ACTIVITY:** Enter the name and address of the organization issuing the document.
- 2a. **DOCUMENT SECURITY CLASSIFICATION:** Enter the overall security classification of the document including special warning terms whenever applicable.
- 2b. **GROUP:** Enter security reclassification group number. The three groups are defined in Appendix 'M' of the DRB Security Regulations.
3. **DOCUMENT TITLE:** Enter the complete document title in all capital letters. Titles in all cases should be unclassified. If a sufficiently descriptive title cannot be selected without classification, show title classification with the usual one-capital-letter abbreviation in parentheses immediately following the title.
4. **DESCRIPTIVE NOTES:** Enter the category of document, e.g. technical report, technical note or technical letter. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.
5. **AUTHOR(S):** Enter the name(s) of author(s) as shown on or in the document. Enter last name, first name, middle initial. If military, show rank. The name of the principal author is an absolute minimum requirement.
6. **DOCUMENT DATE:** Enter the date (month, year) of Establishment approval for publication of the document.
- 7a. **TOTAL NUMBER OF PAGES:** The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.
- 7b. **NUMBER OF REFERENCES:** Enter the total number of references cited in the document.
- 8a. **PROJECT OR GRANT NUMBER:** If appropriate, enter the applicable research and development project or grant number under which the document was written.
- 8b. **CONTRACT NUMBER:** If appropriate, enter the applicable number under which the document was written.
- 9a. **ORIGINATOR'S DOCUMENT NUMBER(S):** Enter the official document number by which the document will be identified and controlled by the originating activity. This number must be unique to this document.
- 9b. **OTHER DOCUMENT NUMBER(S):** If the document has been assigned any other document numbers (either by the originator or by the sponsor), also enter this number(s).
10. **DISTRIBUTION STATEMENT:** Enter any limitations on further dissemination of the document, other than those imposed by security classification, using standard statements such as:
 - (1) "Qualified requesters may obtain copies of this document from their defence documentation center."
 - (2) "Announcement and dissemination of this document is not authorized without prior approval from originating activity."
11. **SUPPLEMENTARY NOTES:** Use for additional explanatory notes.
12. **SPONSORING ACTIVITY:** Enter the name of the departmental project office or laboratory sponsoring the research and development. Include address.
13. **ABSTRACT:** Enter an abstract giving a brief and factual summary of the document, even though it may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall end with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (TS), (S), (C), (R), or (U).

The length of the abstract should be limited to 20 single-spaced standard typewritten lines: 7/4 inches long.
14. **KEY WORDS:** Key words are technically meaningful terms or short phrases that characterize a document and could be helpful in cataloging the document. Key words should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context.